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RESEARCH ARTICLE

Knowledge–attitude–practice gap in zoonotic disease prevention among livestock farmers in Jember, Indonesia: A One Health cross-sectional study

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ABSTRACT

Background and Aim: Zoonotic diseases remain a major public health concern worldwide, particularly in developing countries where close interaction between humans and livestock increases the risk of disease transmission. In Indonesia, zoonoses such as anthrax, leptospirosis, avian influenza, and rabies continue to be reported, highlighting the importance of strengthening prevention strategies through the One Health approach. Livestock farmers represent a high-risk population because of their frequent exposure to animals and contaminated environments. This study aimed to evaluate the knowledge, attitudes, and practices (KAP) related to zoonotic disease prevention among livestock farmers in Jember Regency, East Java, Indonesia, and to examine the relationships among these components to support the development of context-specific prevention strategies.

Materials and Methods: A quantitative cross-sectional study was conducted from March to November 2025 among 683 livestock farmers from 14 subdistricts in Jember Regency, Indonesia. Respondents were selected using purposive sampling and interviewed face-to-face using a structured and validated questionnaire consisting of 19 knowledge items, 9 attitude items, and 15 practice items related to zoonotic disease prevention. Data were analyzed using IBM SPSS Statistics version 27. Descriptive statistics were used to summarize respondents' characteristics and KAP levels, while Chi-square and Fisher's exact tests were applied to assess associations among knowledge, attitudes, and practices.

Results: Most respondents were male (81.3%), aged >45 years (41.6%), and had elementary-level education. Beef cattle and local chickens were the predominant livestock raised. Overall, 62.2% of farmers demonstrated poor knowledge and 92.8% showed poor preventive practices regarding zoonotic diseases, whereas attitudes were generally moderate to good. Higher educational level was associated with improved knowledge and attitudes, although preventive practices remained inadequate across all educational groups. Significant associations were observed between knowledge and attitudes ($p < 0.001$) and between attitudes and practices ($p < 0.001$). However, no direct association was found between knowledge and practices, indicating a persistent knowledge–practice gap among livestock farmers.

Conclusion: Livestock farmers in Jember Regency generally possessed limited knowledge and poor biosecurity practices regarding zoonotic disease prevention despite having relatively positive attitudes. The findings demonstrate that attitudes play a crucial role in translating knowledge into preventive behavior. Strengthening practice-oriented biosecurity training, improving farmer access to hygiene facilities, and enhancing collaboration between veterinary and public health sectors through the One Health framework are essential to improve zoonotic disease prevention among smallholder livestock farmers in Indonesia.

Keywords: attitude, biosecurity, cross-sectional study, Indonesia, knowledge, livestock farmers, One Health, zoonotic diseases.

INTRODUCTION

Zoonoses are diseases transmitted between vertebrate animals and humans and are caused by various pathogens, including viruses, bacteria, fungi, protozoa, and parasites [1, 2]. These infections can spread through multiple transmission routes, including contaminated food and water, airborne exposure, and direct or indirect contact with infected animals. Several major zoonotic diseases, such as Ebola, Middle East Respiratory Syndrome,

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and Coronavirus Disease of 2019, have demonstrated the substantial global health and socioeconomic impact of zoonotic pathogens [3, 4]. Approximately 60% of human infectious pathogens and nearly 75% of emerging infectious diseases identified during the past three decades originated from animals [5]. During the last two decades, zoonotic diseases have caused repeated outbreaks and pandemics across multiple regions worldwide. The WHO has reported at least five major zoonotic outbreaks during this period [6].

In Indonesia, zoonotic diseases such as anthrax, leptospirosis, and avian influenza continue to remain endemic public health problems with fluctuating incidence rates [7, 8]. The COVID-19 pandemic caused by SARS-CoV-2 represents one of the most significant zoonotic events in modern history since its emergence in 2019. According to the WHO, as of August 2025, approximately 778.5 million confirmed cases and more than 7 million deaths had been reported globally, with Indonesia among the countries heavily affected by the pandemic [4]. In addition, zoonotic diseases continue to present serious challenges in Indonesia, as reflected by 431,007 reported rabies-transmitting animal bite cases and 426 associated deaths during 2018–2022, alongside the continuing circulation of avian influenza since 2003. These findings emphasize the urgent need for sustainable zoonotic disease prevention and control strategies. To address these challenges, the Indonesian government has implemented national policies aimed at strengthening zoonotic disease prevention through cross-sectoral collaboration. The One Health approach has emerged as an integrated framework recognizing the interconnection between human, animal, and environmental health in controlling infectious diseases that threaten public health [9]. Within this framework, biosecurity measures, including barn sanitation, hygienic handling of animal products, vaccination, and the use of personal protective equipment, are considered essential preventive strategies [2, 10].

Livestock farmers represent one of the populations at highest risk of zoonotic disease exposure because of their frequent and prolonged contact with animals and potentially contaminated environments containing pathogens such as *Staphylococcus aureus*, *Escherichia coli*, and *Salmonella* spp. [11, 12]. Limited knowledge and inadequate implementation of biosecurity practices among farmers may increase the risk of zoonotic disease transmission not only to farmers themselves but also to surrounding communities [13]. Previous studies have demonstrated that assessing farmers' knowledge, attitudes, and practices (KAP) regarding zoonotic diseases is important for supporting the implementation of effective One Health interventions and identifying behavioral gaps associated with disease prevention [14].

Jember Regency possesses considerable potential for livestock development because of its abundant natural resources, available forage land, and strong human resource capacity supporting livestock production. This is reflected by the positive Ruminant Animal Population Increase value reported in the region, indicating continued capacity for ruminant livestock expansion [15]. Furthermore, economic sector analyses have shown that several livestock commodities in Jember Regency, including goats, sheep, beef cattle, and poultry, have Location Quotient values greater than 1, indicating that these commodities constitute major economic sectors with strong development potential [16]. Despite this potential, the presence of zoonotic pathogens in livestock products remains an important concern. A previous study conducted in Sukowono District, Jember Regency, reported that the prevalence of *Salmonella* spp. contamination on chicken eggs collected from farms and traditional markets reached 25.7%, highlighting the ongoing risk of zoonotic transmission associated with livestock production and product handling in the region [17].

Although several international studies have evaluated farmers' KAP regarding zoonotic disease prevention, evidence from Indonesia remains limited, particularly in smallholder and multispecies livestock production systems that dominate the national livestock sector. Most available studies have focused on specific zoonotic diseases or general livestock management practices, while comprehensive assessments examining the relationships between knowledge, attitudes, and preventive practices among livestock farmers are still scarce. Furthermore, region-specific data describing behavioral determinants associated with zoonotic disease prevention in Jember Regency are currently unavailable. The absence of localized evidence limits the ability of policymakers and public health authorities to develop targeted and contextually appropriate One Health interventions for livestock communities in this region. In addition, there is still limited information regarding how sociodemographic characteristics, farming scale, and livestock type influence farmers' zoonotic disease prevention behaviors within smallholder farming systems in Indonesia.

Therefore, this study was conducted to evaluate the sociodemographic characteristics and levels of KAP regarding zoonotic disease prevention among livestock farmers in Jember Regency, East Java, Indonesia. In addition, this study aimed to examine the relationships among knowledge, attitudes, and preventive practices related to zoonotic diseases within smallholder livestock production systems. The findings of this study are

expected to provide evidence-based and context-specific information to support the development of practical zoonotic disease prevention strategies and strengthen the implementation of the One Health approach among livestock farming communities in Indonesia [18].

MATERIALS AND METHODS

Ethical approval

Ethical approval for this study was obtained from the Health Research Ethics Committee, Faculty of Medicine, University of Jember, Jember, Indonesia, under approval number 1361/UN25.1.10.2/KE/2025. Prior to participation, all respondents were informed regarding the objectives, procedures, benefits, and confidentiality of the study. Written informed consent was obtained from all participants before the interviews were conducted. Participation was entirely voluntary, and respondents were informed that they had the right to withdraw from the study at any stage without any consequences. All collected data were anonymized and used solely for research purposes to ensure participant confidentiality and privacy.

Study period and location

This study was conducted from March to November 2025 in Jember Regency, East Java, Indonesia. Jember Regency is one of the major livestock-producing regions in East Java and is characterized by extensive livestock farming activities involving both ruminant and poultry production systems. Farmers in this region commonly raise beef cattle, dairy cattle, goats, sheep, broiler chickens, laying hens, local chickens, and ducks. The study was carried out in 14 selected subdistricts of Jember Regency, namely Ajung, Ambulu, Arjasa, Gumukmas, Jelbuk, Kalisat, Mayang, Mumbulsari, Pakusari, Panti, Patrang, Silo, Sukorambi, and Sumbersari.

Study design

This study employed a quantitative analytic observational design using a cross-sectional approach to evaluate livestock farmers' KAP regarding zoonotic disease prevention and to examine the relationships among these variables. The study focused on livestock farmers actively involved in daily livestock management activities in Jember Regency, East Java, Indonesia.

Study participants

The study population consisted of livestock farmers involved in raising beef cattle, dairy cattle, goats, sheep, broiler chickens, laying hens, local chickens, and ducks in Jember Regency, East Java, Indonesia. Respondents were considered eligible for inclusion if they fulfilled the following criteria:

- Actively engaged in livestock production within the study area.
- Willing to participate and provide written informed consent.
- Directly involved in daily livestock management activities.

Farmers who failed to complete the questionnaire or withdrew during the interview process before survey completion were excluded from the study.

A preliminary survey was conducted using official data obtained from the Jember Regency Animal Husbandry Service, which reported a total population of 1,105 livestock farmers within the study area. Jember Regency consists of 31 subdistricts, and to ensure adequate geographic representation, a minimum of 30% of the total subdistricts was determined as the minimum sampling coverage. Based on this criterion, 14 subdistricts were selected for inclusion in the study (Figure 1), exceeding the minimum required coverage.

Questionnaire development and data collection

Data were collected directly from respondents using a structured questionnaire developed by the researchers. Seven trained surveyors were involved in the data collection process and received prior training regarding interview procedures, questionnaire administration, and respondent communication. During field implementation, researchers and surveyors conducted interviews simultaneously to ensure direct supervision and consistency during data collection.

The questionnaire was adapted from a previous zoonotic disease KAP study conducted in Bangladesh in 2025 [14]. The adapted questionnaire subsequently underwent translation, cultural adjustment, and validation procedures before implementation to ensure suitability for the Indonesian livestock farming context.

The questionnaire consisted of three main sections assessing farmers' KAP regarding zoonotic disease prevention.

The knowledge section consisted of 19 items designed to evaluate respondents' understanding of zoonotic

diseases and preventive measures. Each item was answered using "Yes" or "No" responses, with correct answers scored as 1 and incorrect answers scored as 0.

The attitude section comprised 9 items assessing respondents' perceptions and attitudes toward zoonotic disease prevention using a five-point Likert scale ranging from strongly disagree to strongly agree.

The practice section consisted of 15 items evaluating routine husbandry and biosecurity practices implemented by farmers during livestock management activities.

Knowledge scores were categorized as poor (0%–49%), moderate (50%–79%), or good (80%–100%). Similarly, attitude scores were categorized as poor/negative (0%–49%), moderate/unsure (50%–79%), or good/positive (80%–100%). Practice scores were categorized as poor/inappropriate (0%–79%) or good/appropriate (80%–100%).

The sample was selected using a non-probability purposive sampling method, in which respondents were recruited based on predefined inclusion criteria relevant to the objectives of the study. A total of 683 livestock farmers participated in this study. Data collection was conducted through face-to-face interviews using a structured questionnaire administered by trained surveyors.

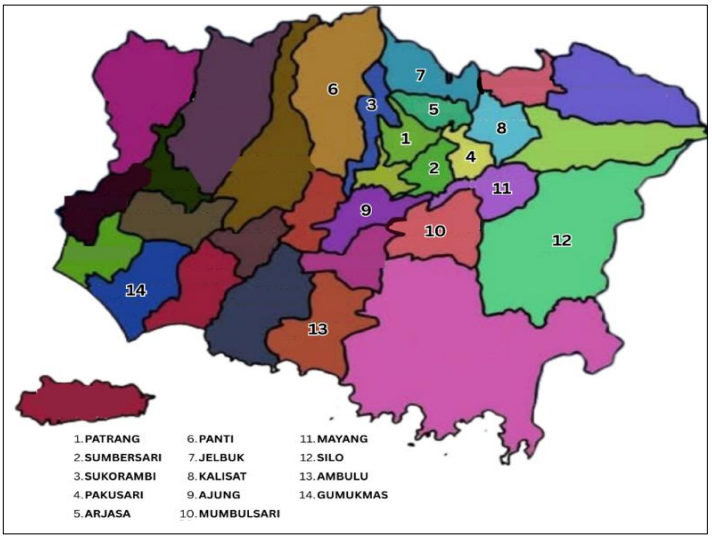

Figure 1: Distribution of study locations in Jember Regency, East Java, Indonesia. The map illustrates the selected subdistricts included in this study for data collection among livestock farmers in Jember Regency, East Java, Indonesia [Source: Jember District Government. (2025). Administrative map of Jember Regency [Map]. Jember District Government].

Validity and reliability testing

Prior to implementation, the questionnaire underwent validity and reliability testing involving 50 livestock farmers from Banyuwangi, East Java, Indonesia. Validity testing demonstrated that all questionnaire items were statistically valid, with significance values below 0.05 ($p < 0.05$).

Reliability analysis demonstrated acceptable internal consistency across all questionnaire domains. Cronbach's alpha coefficients were 0.915 for the knowledge domain, 0.845 for the attitude domain, and 0.785 for the practice domain. These findings indicated that the questionnaire possessed satisfactory validity and reliability and was therefore suitable for use as a research instrument in this study.

Statistical analysis

Data analysis was performed using SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA). Univariate analysis was conducted to describe respondents' sociodemographic characteristics and KAP levels, which were presented as frequencies and percentages.

Bivariate analysis was subsequently performed to evaluate associations among KAP components, specifically the relationships between knowledge and attitudes, attitudes and practices, and knowledge and practices. Statistical associations were analyzed using the Chi-square test or Fisher's exact test when statistical assumptions for the Chi-square test were not fulfilled. Statistical significance was determined at $p < 0.05$.

RESULTS

Demographic characteristics

The sociodemographic characteristics evaluated in this study included age, gender, education level, farming

experience, livestock scale, and livestock type. Based on the survey involving 683 livestock farmers, the largest proportion of respondents belonged to the age group >45 years, whereas the smallest proportion was observed among respondents aged 19–30 years. Male respondents predominated, indicating that livestock farming activities in the study area remain largely managed by men. Based on educational background, most respondents had elementary school education, whereas the smallest proportion consisted of respondents with diploma or bachelor's degrees (Table 1).

Table 1: Characteristics of research subjects.

Characteristics	Number (n)	Percentage
Age		
19–30 years	162	23.7
31–45 years	237	34.7
>45 years	284	41.6
Gender		
Male	555	81.3
Female	128	18.7
Education		
No formal education	57	8.3
Elementary school	270	39.5
Junior high school	129	18.9
Senior high school	188	27.5
Diploma/Bachelor's degree	39	5.7
Years since farming		
1–5 years	287	42.0
6–10 years	92	13.5
>10 years	304	44.5
Livestock scale		
Micro	252	36.9
Small	336	49.2
Medium	95	13.9
Type of livestock		
Beef cattle	176	25.8
Dairy cattle	14	2.0
Goat	147	21.5
Sheep	75	11.0
Broiler chicken	47	6.9
Layer chicken	33	4.8
Free-range chicken	161	23.6
Duck	30	4.4

The distribution of livestock farmers across subdistricts varied according to age and gender, demonstrating differences in demographic structure among study locations. Most subdistricts were dominated by farmers aged >30 years, whereas younger farmers were identified only in a limited number of areas (Table 2).

Table 2: Knowledge, attitudes, and practices analysis based on age.

Age	Knowledge good	Knowledge moderate	Knowledge poor	Attitude good	Attitude moderate	Attitude poor	Practice good	Practice poor
19–30 years (T = 162)	9 (5.6%)	78 (48.1%)	75 (46.3%)	91 (56.2%)	62 (38.3%)	9 (5.6%)	9 (5.6%)	153 (94.4%)
31–45 years (T = 237)	12 (5.1%)	75 (31.6%)	150 (63.3%)	101 (42.6%)	107 (45.1%)	29 (12.2%)	17 (7.2%)	220 (92.8%)
>45 years (T = 284)	7 (2.5%)	77 (27.1%)	200 (70.4%)	60 (21.1%)	167 (58.8%)	57 (20.1%)	23 (8.1%)	261 (91.9%)

Based on farming experience, most respondents had been engaged in livestock farming for >10 years. Regarding farm scale, small-scale farming systems predominated in the study area, with beef cattle identified as the most frequently raised livestock species.

Livestock farmers' KAP regarding zoonotic disease prevention

The findings demonstrated that most livestock farmers had low levels of knowledge regarding zoonotic disease prevention. A total of 425 respondents were categorized as having poor knowledge, whereas 230 respondents demonstrated moderate knowledge and only 28 respondents demonstrated good knowledge (Figure 2a). In contrast, respondents generally demonstrated more favorable attitudes toward zoonotic disease

prevention, with the largest proportion classified within the moderate attitude category (336 respondents), while only 95 respondents (13.9%) demonstrated poor attitudes (Figure 2b). However, preventive practices remained predominantly inadequate, with 634 respondents categorized as having poor practices and only 49 respondents reporting good zoonotic disease prevention practices (Figure 2c).

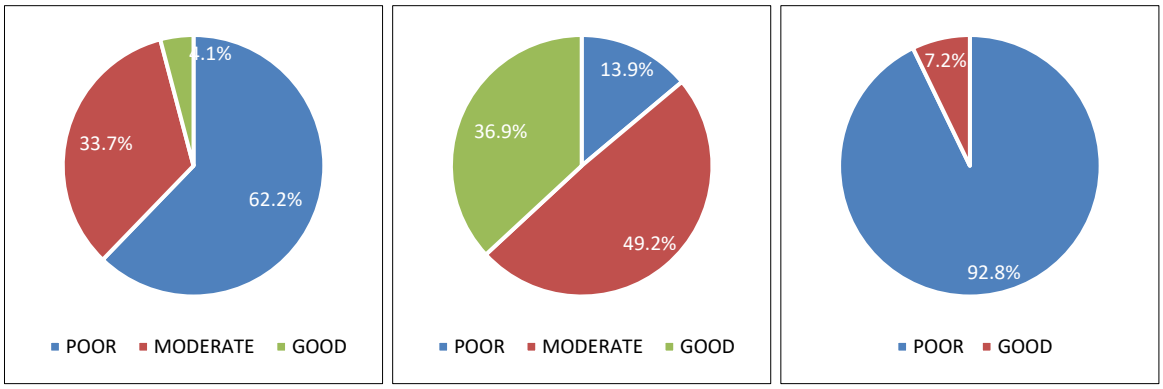

Figure 2: Levels of livestock farmers' KAP regarding zoonotic disease prevention in Jember Regency. (A) Distribution of respondents according to knowledge level regarding zoonotic disease prevention. (B) Distribution of respondents according to attitude level regarding zoonotic disease prevention. (C) Distribution of respondents according to practice level regarding zoonotic disease prevention. KAP = knowledge, attitudes, and practices.

KAP analysis by age

Respondents aged >45 years demonstrated the highest proportion of poor knowledge regarding zoonotic diseases. In contrast, only small proportions of respondents within the 19–30-year (5.6%) and 31–45-year (5.1%) age groups demonstrated good knowledge levels. Regarding attitudes, respondents aged >45 years were predominantly categorized within the moderate attitude group. Interestingly, younger respondents aged 19–30 years demonstrated the highest proportion of good attitudes toward zoonotic disease prevention.

Preventive practices remained poor across all age groups. The highest proportion of poor practices was observed among respondents aged 19–30 years (94.4%), followed by respondents aged 31–45 years (92.8%) and >45 years (91.9%). Although only a small proportion of farmers demonstrated good practices, the findings indicate that preventive biosecurity implementation remains inadequate regardless of age category (Table 2).

KAP analysis by gender

The results demonstrated that both male and female livestock farmers generally possessed limited knowledge regarding zoonotic diseases. Among 555 male respondents, 350 demonstrated poor knowledge, 180 demonstrated moderate knowledge, and only 25 demonstrated good knowledge. Similarly, among 128 female respondents, 75 demonstrated poor knowledge, 50 demonstrated moderate knowledge, and only three demonstrated good knowledge.

Regarding attitudes, most male respondents were classified within the moderate attitude category, followed by the good and poor categories. Among female respondents, 40.6% demonstrated moderate attitudes, 28.9% demonstrated good attitudes, and 30.5% demonstrated poor attitudes.

Preventive practices remained inadequate among both genders. Among male respondents, 91.9% demonstrated poor practices, whereas only 8.1% demonstrated good practices. Similarly, 96.9% of female respondents demonstrated poor practices related to zoonotic disease prevention. These findings indicate that livestock farmers' preventive practices remain low regardless of gender, although male respondents generally demonstrated more positive attitudes than female respondents. Overall, the findings highlight the need for improved educational interventions and practical biosecurity training targeting all livestock farmers to strengthen zoonotic disease prevention practices in the field (Table 3).

Table 3: Knowledge, attitudes, and practices analysis based on gender.

Gender	Knowledge good	Knowledge moderate	Knowledge poor	Attitude good	Attitude moderate	Attitude poor	Practice good	Practice poor
Male (T = 555)	25 (4.5%)	180 (32.4%)	350 (63.1%)	215 (38.7%)	284 (51.2%)	56 (10.1%)	45 (8.1%)	510 (91.9%)
Female (T = 128)	3 (2.3%)	50 (39.1%)	75 (58.6%)	37 (28.9%)	52 (40.6%)	39 (30.5%)	4 (3.1%)	124 (96.9%)

KAP analysis by education

The results of the KAP analysis according to educational background demonstrated that respondents without formal education (n = 57) exhibited the highest proportion of poor knowledge, moderate attitudes, and poor practices. Similar patterns were observed among respondents with elementary school (n = 270) and junior high school education (n = 129), where poor knowledge and practices remained predominant (Table 4).

Among respondents with senior high school education (n = 188), knowledge levels were still predominantly categorized as poor despite generally favorable attitudes. However, preventive practices remained largely inadequate. In contrast, respondents with diploma or bachelor's degrees (n = 39) demonstrated comparatively higher knowledge and more positive attitudes, with most respondents categorized within the moderate knowledge and good attitude groups. Nevertheless, preventive practices among this educational group were still predominantly categorized as poor (Table 4).

Table 4: Knowledge, attitudes, and practices analysis based on education.

Education	Knowledge good	Knowledge moderate	Knowledge poor	Attitude good	Attitude moderate	Attitude poor	Practice good	Practice poor
No formal education (T = 57)	0 (0%)	15 (26.3%)	42 (73.7%)	5 (8.8%)	28 (49.1%)	24 (42.1%)	4 (7.0%)	53 (93.0%)
Elementary school (T = 270)	7 (2.6%)	71 (26.3%)	192 (71.1%)	68 (25.2%)	148 (54.8%)	54 (20.0%)	11 (4.1%)	259 (95.9%)
Junior high school (T = 129)	4 (3.1%)	46 (35.7%)	79 (61.2%)	59 (45.7%)	64 (49.6%)	6 (4.7%)	14 (10.9%)	115 (89.1%)
Senior high school (T = 188)	2 (1.1%)	75 (39.9%)	111 (59.0%)	92 (48.9%)	85 (45.2%)	11 (5.9%)	18 (9.6%)	170 (90.4%)
Diploma/Bachelor's degree (T = 89)	15 (38.5%)	23 (59.0%)	1 (2.6%)	28 (71.8%)	11 (28.2%)	0 (0%)	2 (5.1%)	37 (94.9%)

KAP analysis by farming experience

The KAP analysis according to farming experience demonstrated variations in respondents' knowledge regarding zoonotic diseases across farming duration categories. Among respondents with 1–5 years of farming experience, most demonstrated poor knowledge. Respondents with 6–10 years of farming experience demonstrated a slightly higher proportion of good knowledge (6.5%), although poor knowledge remained predominant (62.0%). Similarly, among respondents with >10 years of farming experience, most demonstrated poor knowledge levels. Overall, knowledge regarding zoonotic diseases remained limited across all farming experience categories (Table 5).

Attitudes toward zoonotic disease prevention were predominantly categorized as moderate across all farming experience groups. Respondents with 1–5 years of farming experience were mainly classified within the moderate attitude category. Similarly, among respondents with 6–10 years of farming experience, moderate attitudes represented the largest proportion (53.3%), followed by good attitudes (38.0%) and poor attitudes (8.7%). A similar distribution pattern was observed among respondents with >10 years of farming experience (Table 5).

Preventive practices remained poor across all farming experience groups. Among respondents with 1–5 years of farming experience, 92.7% demonstrated poor practices, whereas only 7.3% demonstrated good practices. Among respondents with 6–10 years of farming experience, 87.0% demonstrated poor practices and 13.0% demonstrated good practices. Similarly, among respondents with >10 years of farming experience, 94.7% demonstrated poor practices, while only 5.3% demonstrated good practices (Table 5).

Table 5: Knowledge, attitudes, and practices analysis based on years since farming.

Years since farming	Knowledge good	Knowledge moderate	Knowledge poor	Attitude good	Attitude moderate	Attitude poor	Practice good	Practice poor
1–5 years (T = 287)	4 (1.4%)	115 (40.1%)	168 (58.5%)	113 (39.4%)	136 (47.4%)	38 (13.2%)	21 (7.3%)	266 (92.7%)
6–10 years (T = 92)	6 (6.5%)	29 (31.5%)	57 (62.0%)	35 (38.0%)	49 (53.3%)	8 (8.7%)	12 (13.0%)	80 (87.0%)
>10 years (T = 304)	18 (5.9%)	86 (28.3%)	200 (65.8%)	104 (34.2%)	151 (49.7%)	49 (16.1%)	16 (5.3%)	288 (94.7%)

KAP analysis by farm scale

Regarding knowledge, respondents operating micro-scale farms predominantly demonstrated moderate and poor knowledge levels. Small-scale farmers demonstrated similar patterns, with poor knowledge remaining predominant and only a small proportion demonstrating good knowledge. None of the respondents operating medium-scale farms demonstrated good knowledge regarding zoonotic diseases (Table 6).

Distinct differences were observed regarding attitudes according to farm scale. All micro-scale farmers

demonstrated good attitudes, whereas all small-scale farmers demonstrated moderate attitudes, and all medium-scale farmers demonstrated poor attitudes. These findings indicate a declining trend in positive attitudes with increasing farm scale (Table 6).

Regarding preventive practices, most micro-scale farmers still demonstrated poor practices. Among small-scale farmers, the proportion demonstrating poor practices was even higher (94.6%), whereas all medium-scale farmers (100%) demonstrated poor practices. These findings indicate that despite variations in knowledge and attitudes, biosecurity implementation remained inadequate across all farm scales (Table 6).

Table 6: Knowledge, attitudes, and practices analysis based on farm scale.

Farm scale	Knowledge good	Knowledge moderate	Knowledge poor	Attitude good	Attitude moderate	Attitude poor	Practice good	Practice poor
Micro (T = 252)	22 (8.7%)	126 (50.0%)	104 (41.3%)	252 (100%)	0 (0%)	0 (0%)	31 (12.3%)	221 (87.7%)
Small (T = 336)	6 (1.8%)	93 (27.7%)	237 (70.5%)	0 (0%)	336 (100%)	0 (0%)	18 (5.4%)	318 (94.6%)
Medium (T = 95)	0 (0%)	11 (11.6%)	84 (88.4%)	0 (0%)	0 (0%)	95 (100%)	0 (0%)	95 (100%)

KAP analysis by livestock type

KAP analysis of beef cattle farmers: Among 176 beef cattle farmers included in this study, most demonstrated poor knowledge regarding zoonotic diseases (120 respondents), followed by moderate knowledge (50 respondents) and good knowledge (six respondents). Attitudes toward zoonotic disease prevention were predominantly moderate, with 91 respondents categorized within this group, whereas 54 respondents demonstrated good attitudes and 31 respondents demonstrated poor attitudes. Preventive practices remained inadequate, with only 17 respondents demonstrating good practices and 159 respondents categorized as having poor practices (Table 7).

Micro-scale farms demonstrated the highest proportion of respondents with poor knowledge and limited preventive practices despite generally moderate attitudes. Similar patterns were observed among small-scale farms. Although medium-scale farmers tended to demonstrate more favorable attitudes, improvements in preventive practices remained limited, indicating that positive attitudes did not consistently translate into effective zoonotic disease prevention practices.

Table 7: Knowledge, attitudes, and practices analysis based on livestock type.

Type of livestock	Knowledge good	Knowledge moderate	Knowledge poor	Attitude good	Attitude moderate	Attitude poor	Practice good	Practice poor
Beef cattle (T = 176)	6 (3.4%)	50 (28.4%)	120 (68.2%)	54 (30.7%)	91 (51.7%)	31 (17.6%)	17 (9.7%)	159 (90.3%)
Dairy cattle (T = 14)	1 (7.1%)	6 (42.9%)	7 (50.0%)	8 (57.1%)	4 (28.6%)	2 (14.3%)	0 (0%)	14 (100%)
Goat (T = 147)	6 (4.1%)	46 (31.3%)	95 (64.6%)	45 (30.6%)	75 (51.0%)	27 (18.4%)	5 (3.4%)	142 (96.6%)
Sheep (T = 75)	4 (5.3%)	35 (46.7%)	36 (48.0%)	35 (46.7%)	35 (46.7%)	5 (6.7%)	3 (4.0%)	72 (96.0%)
Broiler chicken (T = 47)	4 (8.5%)	21 (44.7%)	22 (46.8%)	24 (51.1%)	18 (38.3%)	5 (10.6%)	3 (6.4%)	44 (93.6%)
Layer chicken (T = 33)	1 (3.0%)	12 (36.4%)	20 (60.6%)	19 (57.6%)	12 (36.4%)	2 (6.1%)	3 (9.1%)	30 (90.9%)
Free-range chicken (T = 161)	5 (3.1%)	51 (31.7%)	105 (65.2%)	57 (35.4%)	85 (52.8%)	19 (11.8%)	16 (9.9%)	145 (90.1%)
Duck (T = 30)	1 (3.3%)	9 (30.0%)	20 (66.7%)	10 (33.3%)	16 (53.3%)	4 (13.3%)	2 (6.7%)	28 (93.3%)

KAP analysis of dairy cattle farmers: Among 14 dairy cattle farmers included in the study, knowledge regarding zoonotic diseases remained limited, with seven respondents categorized as having poor knowledge, six demonstrating moderate knowledge, and only one demonstrating good knowledge. Attitudes toward zoonotic disease prevention were generally favorable, with eight respondents categorized as having good attitudes, while four and two respondents demonstrated moderate and poor attitudes, respectively. However, none of the respondents demonstrated good preventive practices, and all dairy cattle farmers were categorized as having poor zoonotic disease prevention practices (Table 7).

Dairy cattle farming operations in Jember Regency consisted of small- and medium-scale farms. Among small-scale farms (n = 12), most respondents demonstrated poor-to-moderate knowledge levels and none demonstrated good preventive practices despite relatively positive attitudes. Similarly, among medium-scale farms (n = 2), respondents demonstrated moderate-to-poor knowledge levels and positive attitudes; however, preventive practices remained inadequate among all respondents (Table 7).

KAP analysis of sheep farmers: Among 75 sheep farmers surveyed, most demonstrated limited knowledge regarding zoonotic diseases, with 36 respondents categorized as having poor knowledge, 35 demonstrating

moderate knowledge, and only four demonstrating good knowledge. Attitudes toward zoonotic disease prevention were generally favorable, with equal proportions of respondents categorized as having good and moderate attitudes (35 respondents each), whereas only a small proportion demonstrated poor attitudes. Preventive practices remained inadequate, with only three respondents reporting good practices and 72 respondents categorized as having poor practices (Table 7).

When stratified according to farm scale, sheep farming systems in Jember Regency included micro-, small-, and medium-scale farms, all demonstrating similar patterns of moderate-to-poor knowledge and inadequate preventive practices despite relatively favorable attitudes. Good zoonotic disease prevention practices were observed only among a limited number of micro- and small-scale farmers, whereas none of the medium-scale farmers demonstrated adequate practices (Table 7).

KAP analysis of goat farmers: Among 147 goat farmers included in the study, most respondents demonstrated poor knowledge regarding zoonotic diseases, with 95 respondents classified within this category, whereas 46 respondents demonstrated moderate knowledge and only six respondents demonstrated good knowledge. Attitudes toward zoonotic disease prevention were predominantly moderate to good, whereas preventive practices remained inadequate, with only five respondents demonstrating good practices and 142 respondents categorized as having poor practices (Table 7).

Goat farming systems in Jember Regency consisted mainly of micro- and small-scale operations, both demonstrating similar patterns of limited knowledge and inadequate preventive practices despite relatively favorable attitudes. Only a limited number of respondents demonstrated appropriate zoonotic disease prevention practices across all farming categories (Table 7).

KAP analysis of local chicken farmers: Among 161 local chicken farmers included in this study, most respondents demonstrated poor knowledge regarding zoonotic diseases, with 105 respondents categorized within this group, whereas 51 respondents demonstrated moderate knowledge and only five respondents demonstrated good knowledge. Attitudes toward zoonotic disease prevention were generally favorable, with most respondents demonstrating moderate or good attitudes. However, preventive practices remained inadequate, with only 16 respondents demonstrating good practices and 145 respondents categorized as having poor practices (Table 7).

Local chicken farming in Jember Regency was predominantly operated as micro-scale farming systems, which demonstrated limited knowledge and inadequate preventive practices despite relatively favorable attitudes. Small-scale farms demonstrated moderate knowledge and attitudes but consistently poor preventive practices, indicating persistent gaps between awareness and implementation (Table 7).

KAP analysis of broiler chicken farmers: Among 47 broiler chicken farmers surveyed, knowledge regarding zoonotic diseases remained limited, with 22 respondents categorized as having poor knowledge, 21 demonstrating moderate knowledge, and only four demonstrating good knowledge. Attitudes toward zoonotic disease prevention were generally more favorable, with most respondents categorized as having good or moderate attitudes. However, preventive practices remained inadequate, with only three respondents demonstrating good practices and most respondents categorized as having poor practices.

Broiler chicken production systems in Jember Regency consisted of micro-, small-, and medium-scale farms, all demonstrating similar patterns of inadequate preventive practices despite relatively favorable attitudes. Although medium-scale farmers tended to demonstrate better attitudes, only a small number of respondents across all farm scales demonstrated adequate zoonotic disease prevention practices (Table 7).

KAP analysis of laying hen farmers: Laying hen farmers generally demonstrated limited knowledge regarding zoonotic diseases, with most respondents categorized within the poor knowledge category, whereas fewer respondents demonstrated moderate or good knowledge levels. Attitudes toward zoonotic disease prevention were relatively favorable, with most respondents categorized within the good or moderate attitude groups. However, this was not reflected in preventive practices, as only a limited number of respondents demonstrated good husbandry practices and most remained categorized within the poor practice group.

Laying hen farming systems in Jember Regency consisted of micro-, small-, and medium-scale operations, all demonstrating similar patterns of inadequate zoonotic disease prevention practices despite relatively favorable attitudes. Micro-scale farms demonstrated moderate-to-poor knowledge and uniformly poor practices, whereas small- and medium-scale farms demonstrated slightly better knowledge and attitudes but continued to exhibit predominantly poor preventive practices (Table 7).

KAP analysis of duck farmers: Duck farmers generally demonstrated limited knowledge regarding zoonotic diseases, with most respondents categorized within the poor knowledge category and only a small number

demonstrating moderate or good knowledge levels. Attitudes toward zoonotic disease prevention were predominantly moderate, followed by good attitudes. However, preventive practices remained inadequate, with only two respondents demonstrating appropriate preventive practices and most respondents categorized within the poor practice group.

When stratified according to farm scale, duck farming systems in Jember Regency consisted of micro- and small-scale operations, both demonstrating similar patterns of limited knowledge and inadequate preventive practices. Micro-scale farms were characterized by poor knowledge and practices despite predominantly moderate attitudes, whereas small-scale farms demonstrated moderate-to-poor knowledge and uniformly poor preventive practices. These findings indicate persistent gaps between attitudes and implementation of zoonotic disease prevention practices within duck farming systems (Table 7).

DISCUSSION

Sociodemographic characteristics of livestock farmers in Jember Regency

The livestock farmers in Jember Regency were predominantly male (81.26%). Male dominance is common in the traditional livestock subsector because livestock management activities, particularly cattle and goat farming, often require physical labor and high mobility, including searching for feed, handling animals, and herding [19]. Respondents aged >45 years represented the largest age group (41.58%), indicating that livestock farming in rural areas remains an important occupation among middle-aged and older farmers and is commonly managed through traditional farming systems [20]. In contrast, the proportion of young farmers aged 19–30 years was relatively small (23.72%), which is consistent with national trends showing that younger generations are increasingly inclined to work in industrial and service sectors rather than agriculture [21].

Regarding livestock type, beef cattle (176 farmers) and local chickens (161 farmers) were the most commonly raised livestock, whereas dairy cattle were managed by only 14 farmers. The high number of local chicken farmers may be attributed to the relatively low initial investment, lower production risk, and consistent demand for household consumption [22]. Beef cattle are also widely raised because Jember is one of the major livestock development centers in East Java, supported by a favorable market ecosystem and relatively profitable selling prices [23]. Conversely, dairy cattle farming requires higher capital investment, specialized facilities, and more complex feed management, which may limit farmer participation.

KAP of livestock farmers regarding zoonosis prevention in Jember Regency

Overall, goat farmers exhibited the lowest KAP levels among livestock groups, whereas chicken farmers generally demonstrated higher KAP levels. This difference may be explained by the more intensive and commercially oriented nature of poultry farming, which provides farmers with greater access to extension services, training programs, and regular animal health supervision [24]. Chicken farmers also generally have closer interactions with animal health workers, which may encourage better implementation of zoonotic disease prevention measures. Similar findings have been reported in Greece, where improved knowledge and practices were associated with routine veterinary visits and systematic livestock health monitoring [25]. In contrast, most ruminant farmers, including goat and cattle farmers, tend to raise livestock for additional income and local-scale sales rather than fully commercial production [26]. Many goat and cattle farmers in rural areas raise livestock semi-intensively or release animals from pens at certain times, often with limited facilities [27]. Limited interaction with animal health workers and restricted access to extension activities among small-scale farmers may contribute to minimal knowledge of zoonoses and poor zoonotic disease prevention practices [28].

In general, the results of this study indicate that most livestock farmers had better attitudes than knowledge and practices. The marked gap between attitudes and practices suggests that positive beliefs have not been fully translated into actual preventive behavior in the field. This finding is consistent with a study in Ghana, which reported that although livestock farmers showed positive attitudes toward zoonosis prevention, their practices remained poor because of limited facilities, costs, and technical support [29]. The findings of this study are also consistent with several Indonesian studies reporting limited awareness and inconsistent implementation of zoonotic disease prevention among livestock farmers. Previous research in North Sulawesi reported that although communities were aware of certain zoonotic diseases, preventive practices such as using personal protective equipment and proper animal handling remained limited. The poor implementation of zoonosis prevention practices among livestock farmers in Jember may be associated with limited understanding of disease transmission mechanisms and low levels of formal education. Education plays an important role because livestock

farmers with higher educational attainment tend to have better knowledge of zoonotic concepts and stronger adherence to zoonotic disease prevention practices [30]. Furthermore, economic constraints may contribute to poor zoonosis prevention practices. Many livestock farmers cannot afford adequate cage-cleaning facilities, disinfectants, or personal protective equipment. Cost and resource constraints have been reported as major reasons for the failure to implement zoonotic disease prevention practices [14]. Therefore, interventions for livestock farmers should focus on practice-based training, mentoring by animal health workers, and the provision of hygiene facilities as practical strategies to improve zoonotic disease prevention practices.

Based on cross-tabulation, farmers' knowledge and attitudes toward zoonotic diseases tended to decline with age, whereas younger farmers generally demonstrated higher levels of understanding. These findings are consistent with previous research indicating that age is negatively correlated with farmers' knowledge and attitudes [31]. This trend may be related to differences in information-seeking behavior, as younger farmers are more likely to use social media and digital platforms to access information than older farmers [14]. However, the implementation of zoonotic disease prevention practices remained low across all age groups.

Based on gender, both male and female farmers had inadequate knowledge and practices. However, male respondents tended to demonstrate more positive attitudes than female respondents. Previous research has indicated that male respondents may have higher knowledge but lower perceived need for protective practices. This paradox may be attributed to overconfidence in knowledge, which may reduce perceived vulnerability and the perceived need for protection despite better disease understanding. Notably, this finding contrasts with previous research from Ghana, where gender was not a significant factor influencing zoonotic disease prevention behavior [29]. These findings indicate the need for improved knowledge and behavioral guidance for all livestock farmers to strengthen zoonotic disease prevention practices in the field.

Education level influenced respondents' knowledge and attitudes, with higher education levels associated with better knowledge and more positive attitudes. However, this improvement was not fully reflected in practices, as preventive practices remained poor across all educational groups. These findings are consistent with earlier studies reporting no significant differences in practice levels across educational backgrounds, although education influenced knowledge and attitudes [25, 32].

Farming experience was not found to substantially improve respondents' knowledge, attitudes, or practices. This finding is consistent with previous research conducted in Bangladesh, which reported no association between farming experience and KAP related to zoonotic disease prevention [14].

Regarding farm scale, increasing livestock scale did not consistently correspond with improved knowledge of zoonotic disease prevention. Farmers' knowledge of zoonoses in Jember remained low across farm-scale categories, indicating that farm size alone may not improve knowledge, attitudes, or practices related to zoonotic diseases. These findings are consistent with previous studies indicating that herd size does not influence farmers' knowledge regarding zoonotic diseases, as farm size is not necessarily associated with improved awareness of zoonosis prevention [33].

Relationship between KAP among livestock farmers in Jember Regency

The results of this study indicate that knowledge was significantly associated with attitude ($p = 0.000$), suggesting that greater understanding of zoonoses was associated with more positive attitudes toward prevention. This finding aligns with the concept that knowledge forms the basis for developing individual risk perception and awareness [34]. Furthermore, attitude was significantly associated with practice ($p = 0.000$), indicating that positive attitudes may encourage zoonotic disease prevention behaviors, such as maintaining clean pens or separating sick animals. Among livestock farmers in Jember Regency, particularly in areas with high livestock populations such as Arjasa and Kalisat, attitude change is an important determinant because disease control is strongly influenced by habits and values embedded within livestock communities [35].

However, knowledge was not directly associated with practice ($p = 0.136$), indicating a knowledge–practice gap. Many livestock farmers may recognize the risks of disease transmission from animals but fail to implement preventive measures because of costs, ingrained habits, and limited field-based animal health monitoring [18]. In smallholder livestock farming systems in Jember, most livestock-raising activities are still shaped by family experience and economic considerations; therefore, preventive behavior may be influenced more strongly by attitudes and enabling conditions than by theoretical knowledge alone. This finding is consistent with FAO findings indicating that behavioral change among smallholder farmers is more effective when preceded by changes in attitudes and supported by enabling environments rather than through knowledge dissemination alone [36]. The

knowledge–practice gap observed in this study highlights the importance of translating awareness into practical biosecurity measures through integrated One Health interventions. At the district level, this may include strengthening collaboration among veterinary services, public health authorities, and agricultural extension workers to deliver community-based training on zoonotic disease prevention. In addition, integrating zoonosis education into routine livestock extension programs could improve farmers' understanding of disease transmission and encourage adoption of preventive practices. Economic barriers should also be addressed through support mechanisms such as subsidized biosecurity materials or community-based sanitation programs. Such interventions are consistent with the One Health framework, which emphasizes coordinated actions across human, animal, and environmental health sectors.

Relationship between KAP and the One Health approach

The One Health approach represents a strategic framework for the prevention and control of zoonotic diseases by emphasizing the interconnection among human, animal, and environmental health [37]. As infectious disease challenges continue to increase, the scope of One Health extends beyond zoonoses to include emerging and re-emerging diseases, pandemic prevention, preparedness, and response, food safety, neglected tropical diseases, and antimicrobial resistance [38]. Therefore, effective zoonosis control requires an integrated and cross-sectoral approach to ensure sustainable and effective disease prevention.

At the community level, the One Health concept can be operationalized through the implementation of biosecurity measures [2]. Biosecurity comprises systematic procedures aimed at protecting human, animal, and environmental health, including proper housing, sanitation, hygienic processing of animal products, vaccination, and the use of personal protective equipment. In this context, biosecurity serves as an operational embodiment of One Health principles by emphasizing coordination, communication, and cross-sectoral collaboration to maintain a sustainable balance of health [39].

However, the effectiveness of biosecurity implementation is strongly influenced by individual factors, particularly KAP related to zoonosis prevention among groups with high levels of animal exposure. Adequate knowledge and positive attitudes are associated with increased compliance with biosecurity measures, whereas insufficient knowledge and negative attitudes are linked to risky behaviors that may increase the risk of zoonotic transmission and outbreaks [40].

Strengths and limitations

This study provides several important contributions to the understanding of zoonotic disease prevention among livestock farmers in Indonesia. One major strength is the relatively large sample size (n = 683), which allowed a comprehensive assessment of farmers' KAP across Jember Regency. In addition, this study included farmers raising multiple livestock types, including cattle, goats, sheep, and poultry, enabling broader representation of livestock production systems in the region. Another strength is the simultaneous assessment of KAP, which provided insight into the relationships among these components and helped identify the presence of a knowledge–practice gap.

However, several limitations should be acknowledged. This study used a questionnaire-based instrument and therefore relied on respondents' honesty and recall during interviews. Although questionnaire-based research may introduce recall bias and social desirability bias, efforts were made to minimize these limitations through trained surveyors and supervised data collection. Assessment of the practice variable may not fully reflect actual behavior because ideal practice assessment would require direct observation at farm sites without prior awareness by research participants. In addition, the cross-sectional design does not allow causal interpretation and can only identify associations among variables. Another limitation is the use of purposive sampling, which lacks randomization because respondents were selected based on predefined criteria determined by the researchers. Therefore, not all members of the target population had an equal probability of being selected. Nevertheless, this method allowed the inclusion of respondents most relevant to the study objectives and ensured that the collected data aligned with the characteristics being investigated.

Policy translation

From a policy perspective, several practical interventions could be implemented to improve zoonotic disease prevention among livestock farmers in Jember Regency. First, targeted biosecurity training programs should prioritize older farmers and those with lower educational backgrounds, particularly individuals aged >45 years and those with elementary-level education, because these groups represented the largest proportion of farmers

with limited knowledge. Second, the local government could facilitate the provision or subsidized distribution of basic personal protective equipment, such as gloves, boots, and disinfectants, to reduce economic barriers to implementing biosecurity practices. Third, zoonotic disease prevention education could be integrated into existing agricultural extension and livestock health services, allowing regular dissemination of information through veterinary officers and field extension workers. These interventions may help bridge the gap between knowledge, attitudes, and actual preventive practices among livestock farmers.

CONCLUSION

This study demonstrated that livestock farmers in Jember Regency generally had limited knowledge and poor preventive practices regarding zoonotic disease prevention, although their attitudes were mostly moderate to good. Poor knowledge was observed in 62.2% of respondents, and poor practices were reported in 92.8%, indicating a substantial gap between awareness and implementation. Knowledge was significantly associated with attitudes ($p < 0.001$), and attitudes were significantly associated with practices ($p < 0.001$); however, knowledge was not directly associated with practices. These findings confirm the presence of a knowledge–practice gap and suggest that positive attitudes may be a key intermediate factor in translating knowledge into preventive behavior.

The findings have important practical implications for zoonotic disease prevention in smallholder livestock systems. Interventions should move beyond conventional knowledge dissemination and focus on practice-oriented biosecurity training, behavioral reinforcement, routine mentoring by veterinary and livestock extension officers, and improved access to hygiene facilities and personal protective equipment. Priority should be given to older farmers, farmers with lower educational backgrounds, and livestock groups with weaker preventive practices. Integrating zoonosis education into routine agricultural extension services and strengthening collaboration among veterinary, public health, and local government sectors would support more effective implementation of the One Health approach at the community level.

A major strength of this study was the inclusion of a large sample of livestock farmers across multiple subdistricts and livestock types, allowing a broad assessment of KAP patterns in a smallholder farming context. The simultaneous evaluation of KAP also enabled identification of the behavioral pathway underlying zoonotic disease prevention. However, the study had limitations. The cross-sectional design could not establish causal relationships, and questionnaire-based responses may have been affected by recall bias or social desirability bias. In addition, purposive sampling may limit the generalizability of the findings, and self-reported practices may not fully reflect actual farm-level behavior.

Future studies should incorporate direct farm observations, longitudinal designs, and intervention-based evaluations to determine whether targeted biosecurity training and resource support can improve preventive practices over time. Further research should also explore economic, cultural, and infrastructure-related barriers that prevent farmers from applying zoonotic disease prevention measures.

Overall, this study emphasizes that improving zoonotic disease prevention among livestock farmers requires attitude-focused, practice-based, and resource-supported interventions. Strengthening farmer capacity through localized One Health strategies is essential to reduce zoonotic transmission risks and improve animal, human, and environmental health in Jember Regency and similar smallholder livestock settings.

DATA AVAILABILITY

The supplementary data can be made available from the corresponding author upon request.

AUTHORS' CONTRIBUTIONS

DCM, MAS, DA, YA, BH, WSU, and ES: Conceived and designed the study and drafted the manuscript. SCF, JA, FNS, SAH, EMG, MIAW, and MRPA: Conducted interviews and administered the analytic hierarchy process questionnaire. SCF, JA, FNS, SAH, EMG, MIAW, and MRPA: Performed data analysis. DCM, MAS, DA, YA, BH, and WSU: Reviewed the manuscript. All authors have read and approved the final manuscript.

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COMPETING INTERESTS

The authors declare that they have no competing interests.

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